METHODS AND COSTS OF DEEPENING THE CRESCENT SHAFT, BUNKER HILL & SULLIVAN MINING AND CONCENTRATING COMPANY, KELLOGG, SHOSHONE COUNTY, IDAHO

BY E. B. OLDS AND E. W. PARSONS

* * * * * * * * * **Information Circular 7783**

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SUMMARY AND INTRODUCTION

This paper describes the methods and costs of deepening the 3-compartment underground shaft in the Hooper Tunnel adit at the Bunker Hill & Sullivan Mining and Concentrating Company Crescent mine in the Coeur d'Alene mining region, 7 miles east of Kellogg, Shoshone County, Idaho. The work was done with the aid of a Defense Minerals Exploration Administration contract (No. Idm-E493, Docket No. DMEA-2764).

Preparation for deepening the shaft was begun March 26, 1953, and sinking was completed May 27, 1954. The shaft, bottomed at 1,275.5 feet in 1939, was deepened to 3,276 feet, using mechanical mucking and intermediate pockets. A total of 50,349 man-hours was required to complete the work of sinking 2,000.5 feet, cutting 7 pump stations, and driving 2 pocket raises. The rate of advance was 7.1 feet of shaft per operating day, or 8.4 feet per day of actual sinking. The total direct cost for sinking was $205.20 per foot.

ACKNOWLEDGMENTS

The authors are indebted to S. W. McDougall, manager of mines, Bunker Hill & Sullivan Mining and Concentrating Company, for his cooperation during the progress of the work and for permission to publish this report. The information herein presented was taken from a thesis by E. B. Olds, submitted to the faculty of the Mackay School of Mines, University of Nevada, in partial fulfillment of the requirements for the degree of engineer in mines, and is published by permission of the Dean, Mackay School of Mines.

DESCRIPTION OF DEPOSIT

The Crescent shaft extension is in the St. Regis formation of the Precambrian Belt series. This series is made up of the Prichard, Burke, Revett, St. Regis, Wallace, and Striped Peak formations, aggregating over 20,000 feet in thickness.

The St. Regis formation consists of argillaceous quartzites and gray to lavender quartzites, some of which are limy. Beds vary from an inch or less to several feet in thickness but are usually less than 1 foot thick. Hydrothermal alteration is visible in well-defined "bleached" zones where the originally purple and lavender colors have been changed to a shade of green.

Where exposed in the Crescent mine, the St. Regis formation dips steeply, often vertically or even overturned. On the 3,200-foot level the formation is folded into an anticlinal and a synclinal structure. The formation, as exposed in the Crescent mine, is bounded on the north by the Syndicate fault and on the south in part by the Alhambra fault.3/

3/ Shenon, P. J., and McConnel, R. H., The Silver Belt of the Coeur d'Alene District, Idaho: Idaho Bureau of Min. and Geol., Pamph. 50, 2d ed., October 1939, 9 pp.

The Crescent mine lies between the Bunker Hill mine (the largest lead-zinc mine in the Coeur d'Alene district) and the Sunshine mine (the largest copper-silver mine in the district). The latter also produces substantial quantities of lead from the lower levels.

HISTORY

Mining at the Crescent mine was begun before 1917, but no records of production before that time are available. After 1917 the mine produced 4,383,000 pounds of lead, 2,746,000 pounds of copper, and 6,078,000 ounces of silver. Operations ceased in 1942 because known ore bodies were nearing exhaustion and manpower was scarce during the war years.

When work began on the exploration project, mine openings consisted of 5 surface adits and 7 sublevels. The lowest of these adits was the Hooper tunnel, about 5,000 feet long. From this level a 3-compartment vertical shaft extended 1,275 feet; from this shaft 5 levels had been driven (fig. 1). Virtually all of the work had been confined to the immediate vicinity of the Alhambra fault and was directed to development of ore shoots in or near this structure.

PURPOSE OF SHAFT

Deepening of the Crescent shaft was undertaken to prospect the entire block of ground between the Alhambra and Syndicate faults for lead-zinc and silver-copper ore bodies at depth. Since experience in the district, particularly at the Bunker Hill mine on the west and the Sunshine mine on the east, indicates that many of the more valuable ore bodies lie at depths of sea level or lower (3,000 to 5,000 feet below the surface), the company decided to deepen the Crescent shaft 2,000 feet to a level 400 feet below sea level. This horizon was chosen so that if developments were favorable the workings could ultimately connect with the company Bunker Hill mine workings.

Proposed development from the shaft bottom was to include 9,000 feet of crosscuts and drifts and probing by diamond drilling from this work.

The Hooper tunnel portal and surface buildings are on the east slope of Big Creek Canyon. The collar of the underground shaft, elevation 2,709 feet, is in the Hooper tunnel (about 4,000 feet west of the portal) 5,300 feet in a westerly direction from the Sunshine Mining Co. Jewel shaft and 11,000 feet in an easterly direction from the nearest workings of the Bunker Hill mine.

REHABILITATION OF SURFACE AND UNDERGROUND PLANT

The old Crescent mine office and change house, conveniently near the portal of the Hooper tunnel, were reconditioned. Shop facilities were not considered necessary; all machine-shop work and timber framing were to be done in the Bunker Hill mine shops. A charging panel to handle 30 Edison miners' lamps was installed in the old shop building.

Tracks in the mine yard were repaired, and a 1 1/2-ton electrically driven chain hoist was installed on an "I" beam over the surface tail track to expedite handling of supplies and equipment hauled from the company Kellogg warehouses and shop. All timber was delivered "packaged" to the shaft collar.

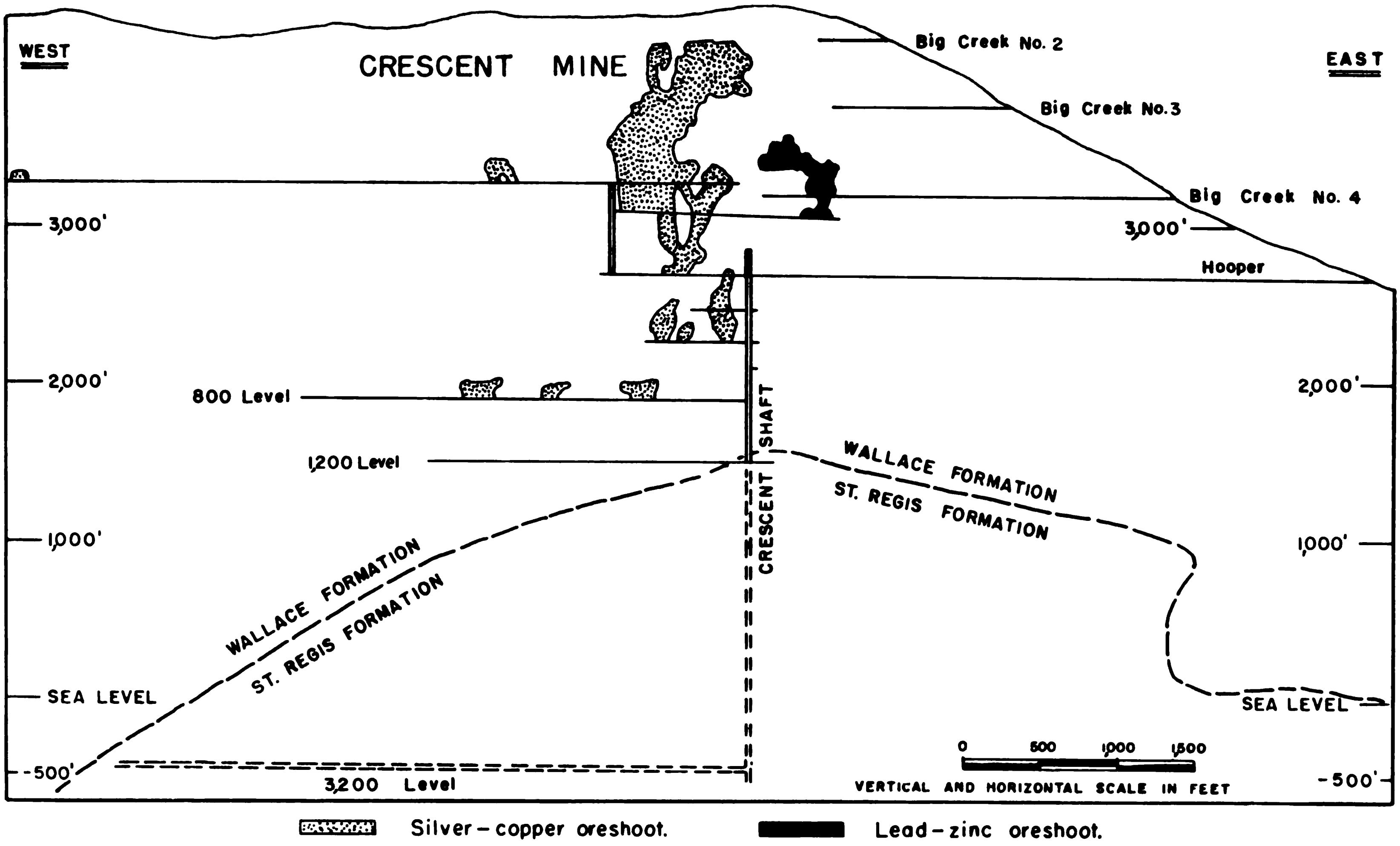


Figure 1. - Vertical section of Crescent mine showing location of shaft.

About 300 feet of old waste track trestle was repaired and a dump constructed that would handle Bunker Hill-type bottom-dump cars. A 400-ton-capacity bin was built on the hillside below the trestle by erecting a retaining wall with side wings and using the natural surface for the bottom. A chute lip was installed, and the bin was equipped with a three-drum tugger hoist and scraper to load into a dump truck that hauled waste rock about one-fourth mile to a dump.

The rolling stock consisted of eight 4.2-ton Bunker Hill-type bottom-dump mine cars, 7 timber trucks, one 6-ton battery locomotive, and 1 battery-powered 32-volt "speeder" locomotive for transportation of workmen.

The Hooper tunnel adit was cleaned and rehabilitated as far as the collar of the shaft, and 24-inch gage track was laid using 85-pound re-lay rail. Shaft timber was replaced from the collar to the sheave wheels, a distance of about 100 feet, and the shaft ore bins were repaired.

A deep-well-type pump was used to dewater the shaft and old workings. A 100-hp. pump with a rated capacity of 400 g.p.m. at 700-foot head was mounted on a crosshead fitted to the shaft guides. By using air jets in the water column the pump was able to operate down to the 800-foot level. When pumping was begun, no hoist was available, so 2 lightweight 5-ton chain hoists with 40-foot lift chains were used to lower the pump. A cable from the collar station supported the chain hoists and pump. When dewatering was completed to the 800-foot level, a 500-g.p.m., 800-foot-head motor pump was installed on the 800-foot level to relay the water from a temporary sump to the top. The deep-well pump continued working below the 800-foot level and discharged into the temporary sump until the dewatering was completed to the 1,200-foot level. As dewatering progressed, new ladders, platforms, 6-inch pump column, 6-inch air line, 2-inch waterline, and 20-inch ventilation pipe were installed in the manway compartment.

The shaft hoist, built by Bunker Hill & Sullivan, was powered by a 2,300-volt, 250-hp.-a.c. motor and equipped with dynamic braking. The drums of the double-drum hoist were 4 feet in diameter and 4 feet in length, each equipped with 3,817 feet of 7/8-inch flattened-strand wire rope. The rope speed was 800 feet per minute. Two 48-inch-diameter sheaves were placed at the junction of the top of the shaft, and a 121-foot, 47° inclined rope raise. (See fig. 2 for shaft-station layout.)

A 30-inch-diameter fan powered by a 50-hp. motor was west of the shaft and moved 28,000 c.f.m. of air, incast in the Hooper tunnel, exhausting it through old workings to No. 4 adit level, 565 feet above the Hooper level.

Two 400-c.f.m. air compressors were installed between the collar of the shaft and the fan. They were powered by 2,300-volt, 100-hp. motors and furnished air at 115 pounds pressure. A water-cooled aftercooler and an automatic unloading trap were placed between the compressors and air receivers. Water for the aftercooler was circulated from the drainage ditch by a 1/3-hp. basement-type pump.

A 25-hp. blower was set in the manway compartment 60 feet above the collar of the shaft and delivered about 6,000 c.f.m. of air through the 20-inch ventilation pipe to the bottom of the shaft during sinking operations. A second 25-hp. blower was installed at the collar station. By regulating dampers this second blower exhausted about 5,300 c.f.m. of air from the shaft bottom after blasting.

The collar station was equipped with two 1-1/2-ton chain blocks mounted on "I"-beam crawls for the unloading of timber, equipment, and supplies.

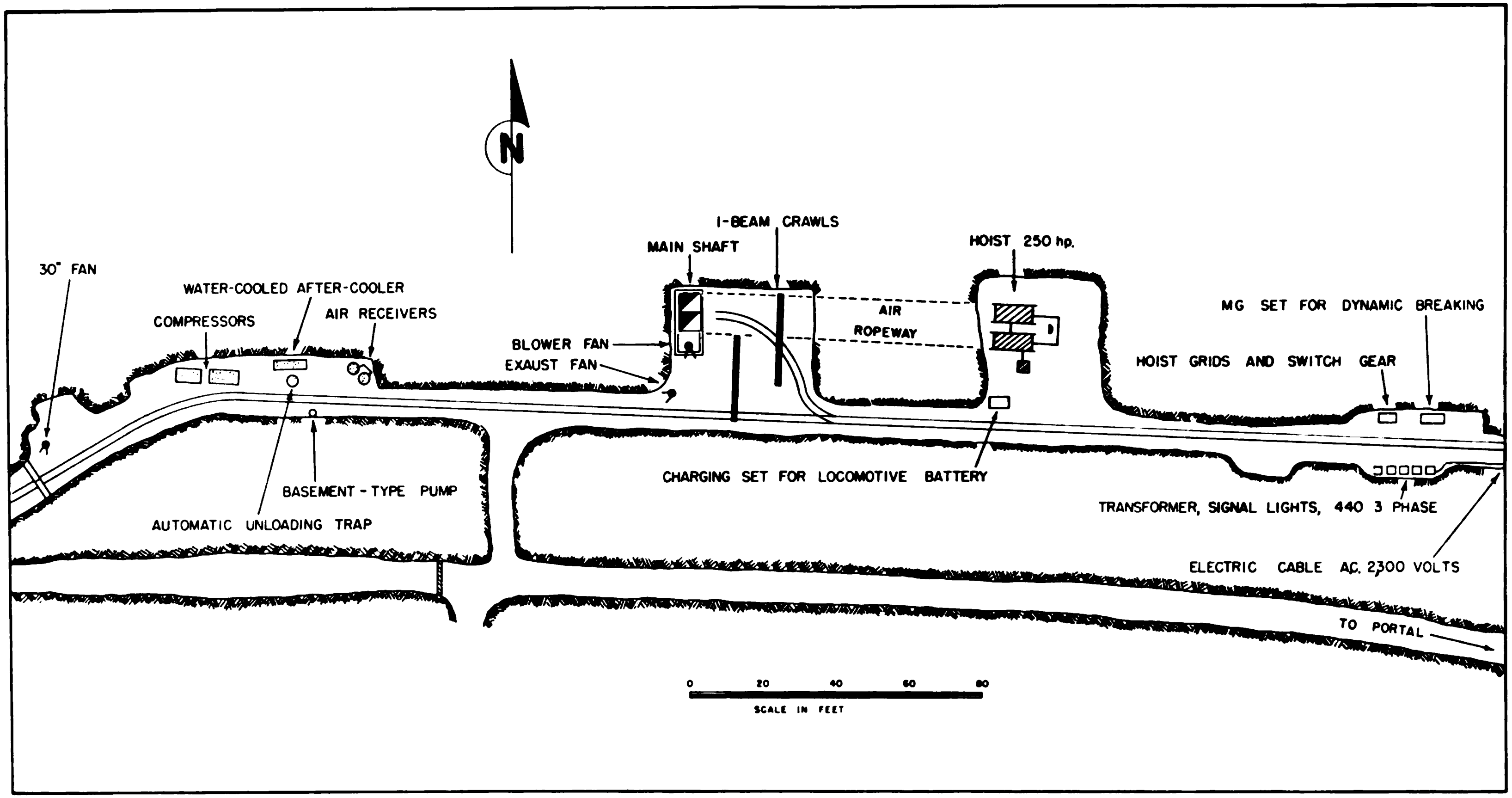

N
30" FAN
WATER-COOLED AFTER-COOLER
COMPRESSORS
AIR RECEIVERS
BLOWER FAN
EXAUST FAN
MAIN SHAFT
I-BEAM CRAWLS
AIR
ROPEWAY
HOIST 250 hp.
MG SET FOR DYNAMIC BREAKING
HOIST GRIDS AND SWITCH GEAR
BASEMENT - TYPE PUMP
AUTOMATIC UNLOADING TRAP
CHARGING SET FOR LOCOMOTIVE BATTERY
TRANSFORMER, SIGNAL LIGHTS, 440 3 PHASE
ELECTRIC CABLE A.C. 2300 VOLTS
TO PORTAL
0
20
40
60
80
SCALE IN FEET

Figure 2. - Equipment at shaft station on Hooper level.

A motor-generator set and facilities for charging locomotive batteries were installed in the hoistroom.

Electric power entered the mine adit in an armored No. 2-0, 3-conductor cable, and was taken down the shaft in a No. 2, 3-conductor, borehole-type, varnished-cambric, lead-sheathed cable.

Two automatically controlled motor pumps, with a combined capacity of 700 g.p.m. at a 1,250-foot head, were set on the 1,200-foot level and pumped from a station sump. These pumps were manually controlled during sinking operations and, in order to prevent peaks in the power load, were operated during the drilling cycle only. A selector switch made it possible to use either pump. About 75 g.p.m. was pumped from the 1,200-foot level, mostly from the old workings.

SHAFT SINKING

The sinking of 2,000.5 feet of timbered shaft from the 1,275.5-foot level, which was the bottom of the old Crescent shaft, to the 3,276-foot level was accomplished in 284 operating days. The work included the excavation of 4 pump stations, 1 intermediate shaft pocket station with skip load station and pocket raise, and a portion of the main 3,200-foot level station, loading station, and pocket raise. The total time spent on each operation was: Shaft sinking, 238 2/3 days; station cutting, 41 1/3 days; and breakdown time, 4 days, for a total of 284 days. The rate of progress was 8.4 feet of shaft per shaft sinking day or 7.1 feet per operating day.

The 3-compartment shaft was 15 feet by 5 feet 10 inches. The 2 hoisting compartments were 54 by 48 inches inside the timber, and the manway compartment was 54 by 52 inches.

A Riddell shaft mucker equipped with a 3/8-cubic-yard clamshell bucket loading into 21-cubic-foot sinking buckets was used during sinking operations.

In addition to a standard shaft signaling system, intercommunication systems were installed between the hoistroom, intermediate dump station, and intermediate loading pocket and between the hoistroom and the bottom pump station.

The 20-inch ventilation line, 6-inch pump column, 6-inch air line, 2-inch waterline, and power cable were carried in the manway compartment.

The hoist speed of 800 feet per minute was considered too slow for hoisting the broken rock in 1 lift. To speed operations during mucking, the loaded sinking buckets were emptied into intermediate shaft pockets that were never more than 1,275 feet above the bottom of the shaft, thereby permitting a fairly uniform rate of advance. The first intermediate pocket was installed on the old 1,200-foot level, using the pocket already cut, and the second intermediate pocket was cut on the 2,000-foot level when the shaft was down to the 2,100-foot level.

The intermediate shaft pockets were equipped with 2 semicircular steel aprons, 1 in each hoisting compartment (fig. 3). Each apron was fastened at the bottom with a hinge and lowered across the shaft or brought up into clear position by a screw mechanism driven by a 5-hp. electric motor. Limit switches were installed on both sides of the screw mechanism to stop the aprons automatically in their correct positions. An operator controlled the position of the apron with conveniently located switches.

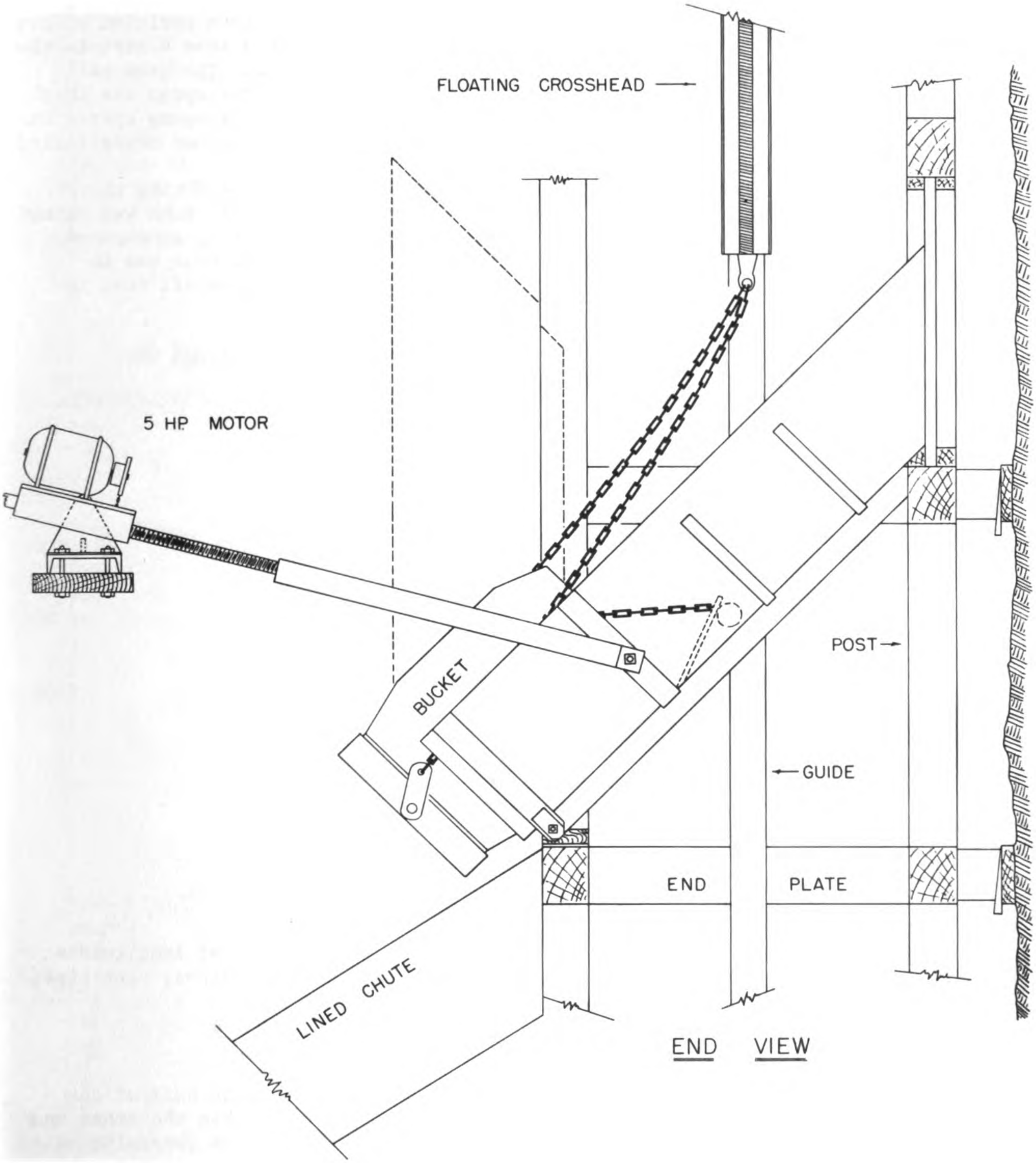


Figure 3. - Intermediate pocket dump station.

Operation of the dumping device depended on an iron ball suspended by a 3-foot chain from the bottom of the sinking bucket. The loaded bucket was hoisted to a point above the intermediate pocket apron and the apron lowered into position across the shaft. The bucket was then lowered; and the iron ball hooked in a V-slot in the apron, causing the bucket to turn over and empty into the pocket. The iron ball disengaged as the empty bucket was hoisted to clear the apron. The apron was then pulled clear and the bucket returned to the bottom. The complete dumping operation required 20 seconds, during which time another bucket was at the bottom being filled.

Muck from the intermediate shaft pocket was hoisted with skips during the drilling cycle. To protect the men in the bottom of the shaft while muck was being hoisted, a temporary bulkhead of lagging was placed across 1 hoisting compartment about 4 sets below the intermediate pocket chute lip, a deflection door was installed in the other hoisting compartment, and the manway was lagged off from the loading pocket to the bulkhead.

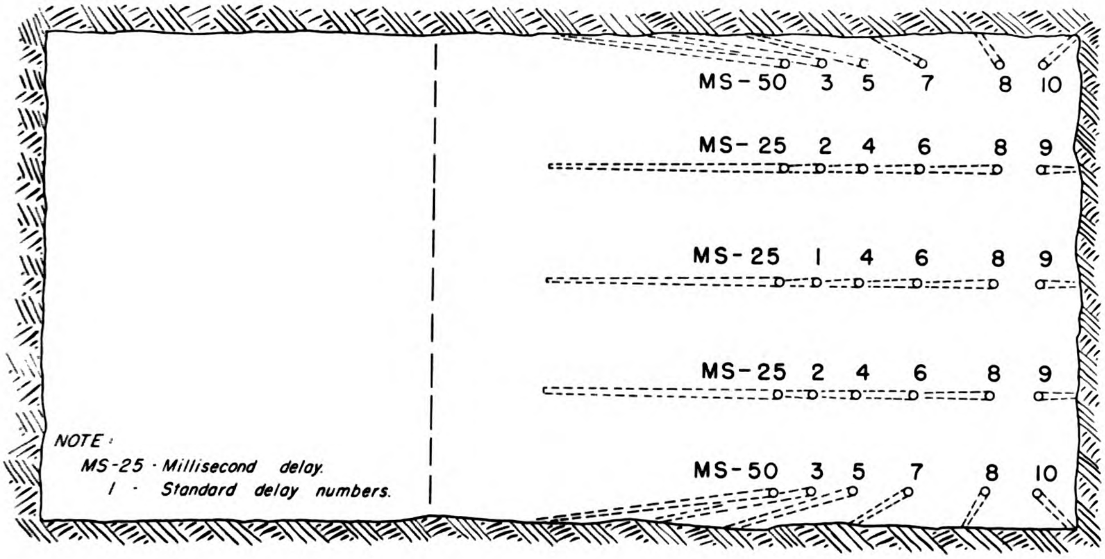
The average time of operations during sinking for each bench round was:

Drilling cycle:		
Drill	2 hours	
Load		30 minutes
Setup and teardown		30 minutes
Smoke clearance		30 minutes
Total	3 hours	30 minutes
Mucking cycle:		
Muck	1 hour	30 minutes
Bar down and clean fly rock from timber		30 minutes
Total	2 hours	
Timbering cycle:		
Lower "Battleship"		12 minutes
Hang and block set	1 hour	10 minutes
Lower mucker		13 minutes
Dividers and lagging.		30 minutes
Short guides		8 minutes
Total	2 hours	13 minutes
Total time	7 hours	43 minutes

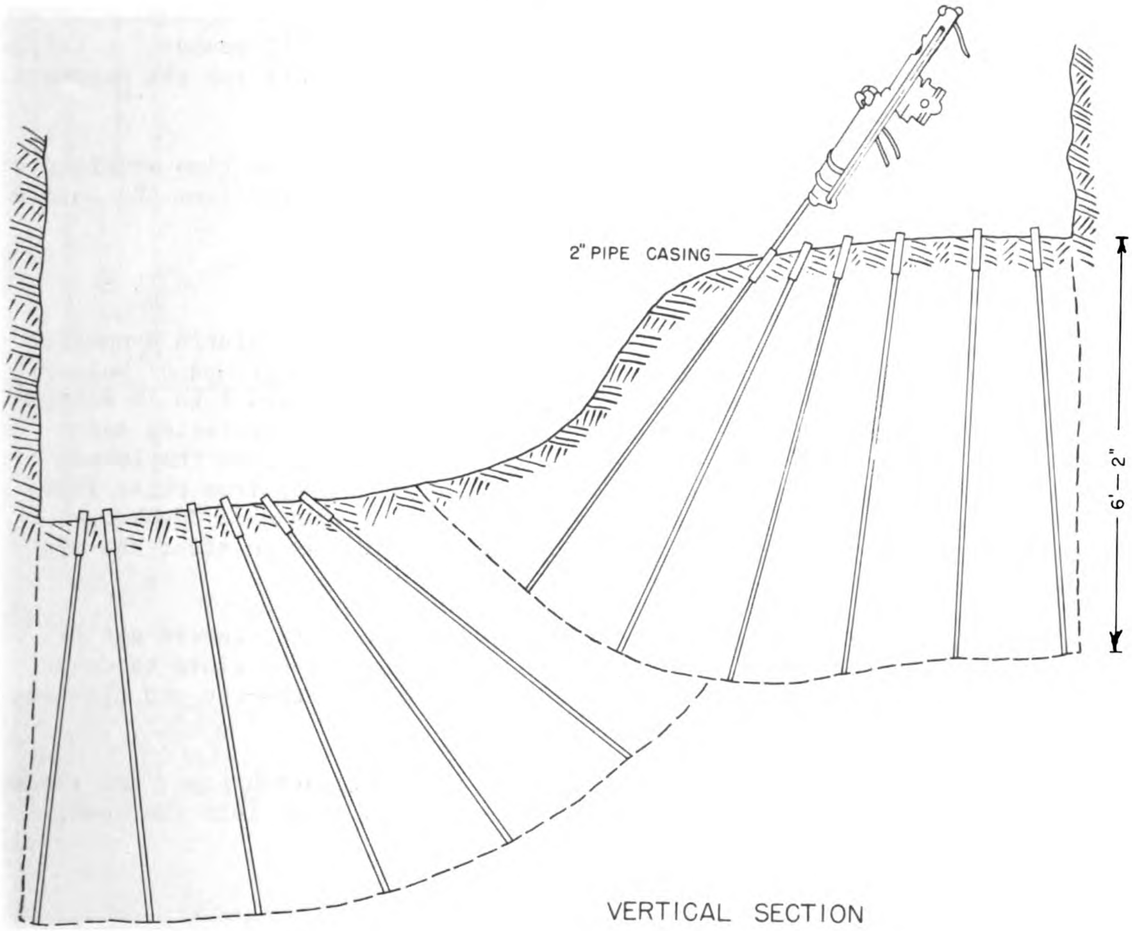
Additional time required every third set for the installation of long guides was 35 minutes, and every fourth or fifth set the installation of pipes, vent pipe, ladders, and landings required 3 hours.

Drilling

A normal sump or bench-type round of 30 holes was used to break half of the shaft bottom at a time (fig. 4). Thus one side was always lower than the other and served as a sump. Final hand mucking was eliminated; all loose rock remaining on the high bench following mechanical mucking was air-swept into the sump with a blow pipe. A round consisted of five rows of six 8-foot holes that broke an average of 6.2 feet for an overall shaft advance of 3.1 feet per round.



PLAN



VERTICAL SECTION

Figure 4. - Bench round used in Crescent shaft.

Drilling was with two 3-inch power-feed drifters using a 30-inch steel change. A 3-inch pneumatic bar was placed horizontally across the short axis and about 30 inches from the end of the shaft to be drilled for the support of 2 drifters. To prevent the bar from rotating, one end was equipped with two steel stingers that were inserted into short drill holes in the side wall; the other end had a conventional single-point stinger. A complete round was drilled from one setup.

Using a 2-1/2-inch detachable bit, holes were collared to solid ground and cased with short pieces of 2-inch pipe. The holes were drilled with 1-1/8-inch round, lugged, hollow drill steel equipped with carbide-insert detachable bits. New bits were all 1-5/8-inch and gage changes were obtained by sizing the bits after sharpening. Excessive thread wear on drill rods and bits was reduced by changing the drifters to down-stroke rotation.

Results of a drill test on alloy and high-carbon steel rod indicated that failure in alloy rod was usually due to spalling of the threads, which resulted in loss of bits; failure in high-carbon steel rod was in the rod itself, and the bits could be recovered. Footage per rod for each type was about equal.

Drill water was obtained from the old 1,200-foot level sump. Pressure-reducing valves were installed in the line as needed to protect equipment from excessive pressure.

Air pressure at the compressors was held between 110 and 115 pounds. A 1-1/2-inch hose connected the shaft air line to a manifold with outlets for the pneumatic bar, drifters, and blowpipe.

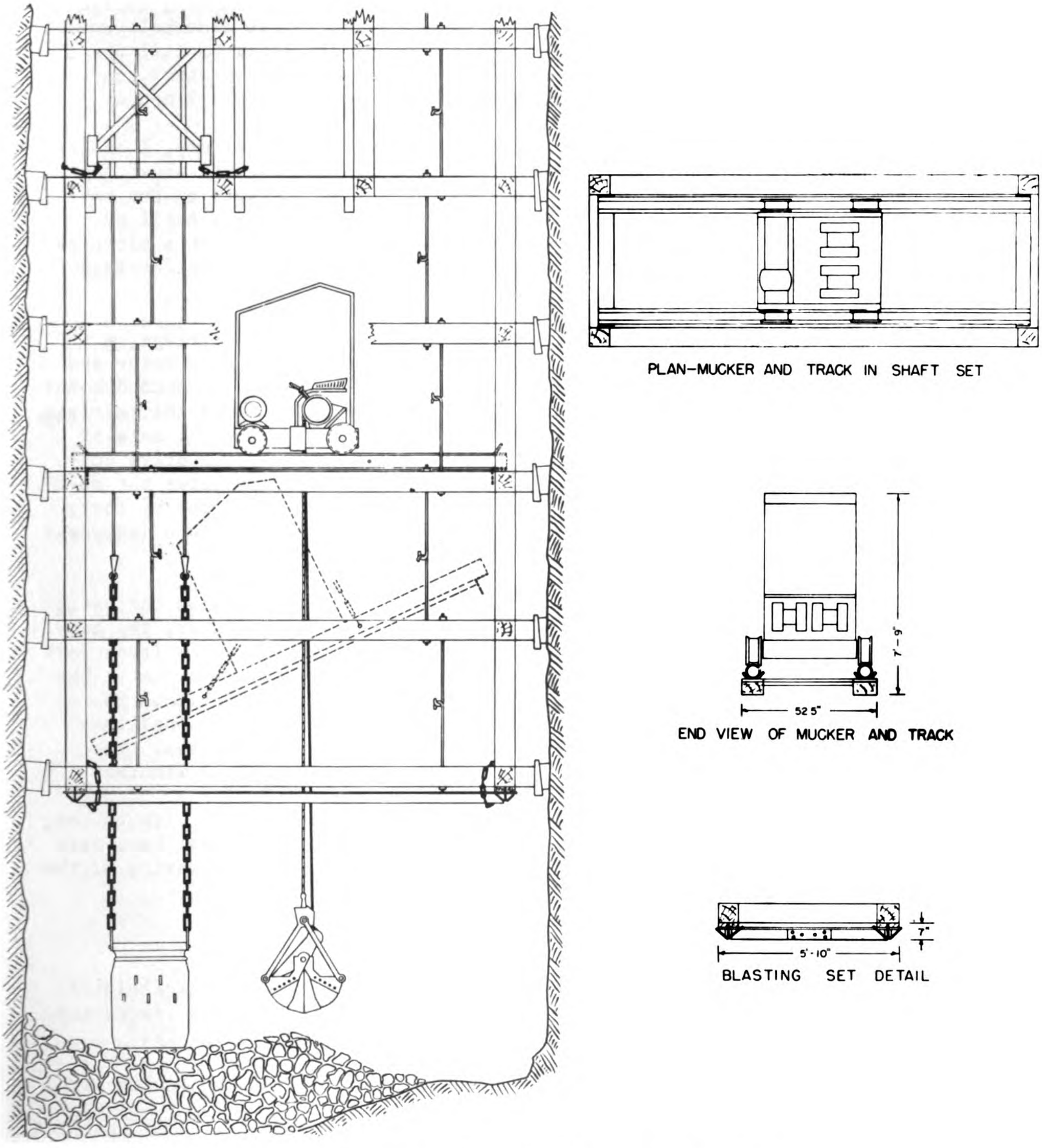
Four men drilled a shaft round in 2 hours; setup and teardown time required an additional 30 minutes. During the drilling cycle muck was hoisted from the intermediate pocket to the collar ore pocket.

Blasting

The holes were loaded with 1-1/8-inch by 8-inch 45 percent gelatin dynamite and detonated with electric delay blasting caps. The first two groups of holes in the round were fired by millisecond-delay detonators, but standard 1 to 10 delays were used in the remainder (fig. 4). The detonators were wired in series and checked with a galvonometer. A two-wire blasting line was hung from the lowest pump station to the bottom, in the end hoisting compartment away from other lines and pipe, and connected to the detonator circuit. Using a condenser discharge blasting machine, the round was fired from the lowest pump station after the men and skip had been hoisted above that point.

A steel blasting set or "Battleship" was used to protect the lowest set of timber from flying rock (fig. 5). It was built of 3/4-inch steel plate to cover the bottom surfaces of the set and was hung by chains against the set and tightened with wedges.

Blasting fumes were exhausted through the 20-inch ventilation pipe; and about 30 minutes was required to clear the smoke. Fresh air was blown into the shaft during the rest of the working cycle.


PLAN–MUCKER AND TRACK IN SHAFT SET

END VIEW OF MUCKER AND TRACK

BLASTING SET DETAIL

Figure 5. - Riddell shaft mucker and blasting set.

Mucking

Broken rock in the shaft bottom was loaded into 21-cubic-foot sinking buckets by a Riddell mechanical shaft mucker equipped with a 3/8-cubic-yard clamshell bucket (figs. 5 and 6). Normally 3 passes of the clamshell were sufficient to fill the bucket and required 1 to 1-1/2 minutes. Average time for loading, hoisting, and dumping 30 buckets was 1 hour, and the complete mucking cycle required 2 hours.

During the mucking cycle a skiptender operated the intermediate dump, 1 shaftman operated the mucking machine, another shaftman stationed on the set above the mucking machine signaled the hoistman, and the other 2 shaftmen stayed on the bottom. One of the bottom men barred down while the other guided the clamshell by means of a rope. When mucking was finished and the bench air-swept with a blowpipe, the clamshell was hoisted and chained under the machine carriage and the carriage moved to the manway compartment.

The Riddell shaft mucker consists of three principal parts - a carriage, a track frame, and a clamshell bucket (fig. 5). Two air hoists and an air motor are mounted on the carriage; one hoist raises and lowers the clamshell, the second hoist is used to open and close the clamshell bucket, and the air motor moves the carriage and suspended load back and forth on the track frame along the horizontal axis of the shaft. The carriage is mounted on flanged wheels driven by a chain drive connected to the traction air motor. One man riding on the carriage operates the machine; the clamshell hoists are controlled by hand and the traction motor by foot. One experienced operator was available when the work started, but within a few weeks 2 men on each of the 3 shifts could handle the machine.

The mucking machine was operated from the second set of timber above the bottom set and was lowered one set at a time as new timber was placed. To lower, the carriage was secured in the center of the frame; and chains, attached to the frame fore and aft on both sides of the carriage, were hooked over the rim of the bucket. The chains, longer on one end, caused the suspended frame to hang in an inclined position, thereby providing clearance for lowering. After the frame was in position, safety chains were placed at both ends to hold the frame on the end plates. The average time for lowering the mucker and placing it in operation was 13 minutes.

The 3/8-cubic-yard clamshell bucket was a heavy-duty-type equipped with bottom, side, and corner teeth. Before placing in operation, 3/4-inch mild steel bars were welded around the attachment end of the bottom teeth to help prevent shearing of the teeth bolts.

Timbering

A complete set of timber was lowered from the collar in one trip. Wallplates were hung under the cage on timber clevises, and the rest of the set was loaded into the bucket and cage. Four 7/8-inch hanging rods were used per set (fig. 7).

The steel blasting set, suspended by chains about 8 feet below the bottom set and lagged over, was used as a staging while timbering.

Guides were installed to the fourth set from the bottom, and 5-1/2-foot sections were added upon the completion of each set. At the completion of every third set the short guides were removed from 2 sets, and standard 4- by 6-inch by 16-1/2-foot guides were installed. Dividers were not placed in the bottom three sets because they would interfere with the operation of the mucking machine. The average

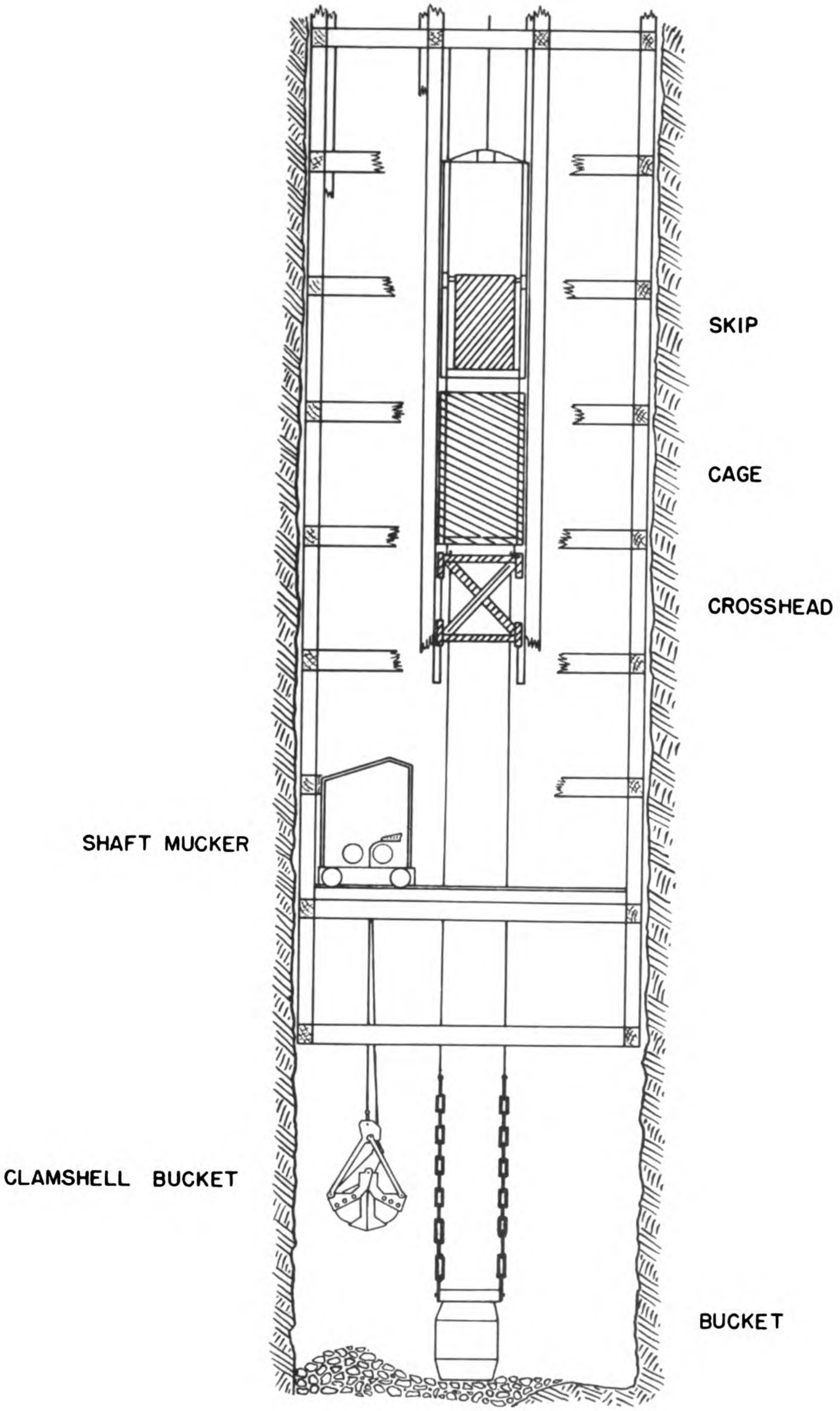


Figure 6. - Shaft-sinking assembly.

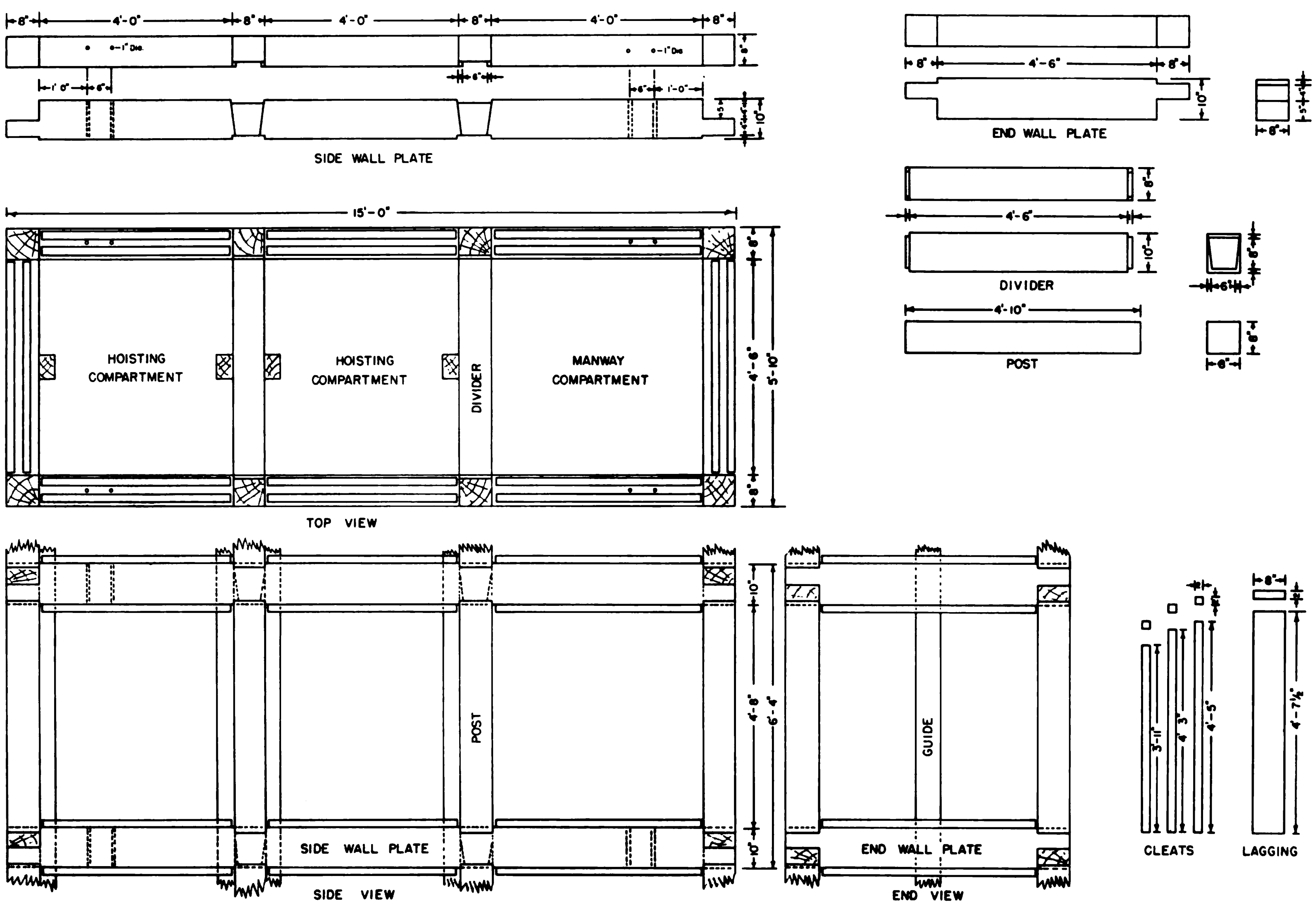


Figure 7. - Shaft-timber detail.

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time for placing a set of timber was 2 hours and 43 minutes, and 35 minutes additional time was required every third set for placing the long guides. Sets were carried to within about 12 feet of the bottom.

A novel type of bearing set, placed every 400 feet, was a departure from standard practice (fig. 8). The bearing set was identical with the regular sets but was supported by 8 rock bolts 1-1/2 inches in diameter and 6 feet long. Each bolt had an eye formed and welded shut on one end. Holes of the proper length were drilled in the side walls at an angle of 40 degrees from vertical, and the bolt was placed so the eye was over the center line of the wallplate and a foot above it. Short 1-1/2-inch bolts with a hook on one end and threaded on the other were placed in vertical holes in the wallplate and hooked into the eye of the rock bolt. A steel plate washer with a nut was used to tighten the set in place. Split cedar lagging was wedged under the rock bolt between the wall rock, short bolt, and wallplate.

Two plumb lines at diagonal corners of the shaft were used to aline the sets while blocking them into position.

All timber used in the shaft was treated with a preservative.

Pumping

The shaft made about 10 gallons of water per minute.

Intermediate pump stations, 15 by 15 feet and 10 feet high, were excavated at each 400-foot interval below the 1,200-foot level. Each pump station was equipped with a 25-hp. motor pump that pumped from a steel tank 3 feet wide, 4 feet high, by 10 feet long. An air sump pump was used in the shaft bottom. At high heads an air jet in the pump column was used to boost the ultimate head, or two sump pumps were used in tandem. When the bottom of the shaft reached a point about 240 feet below an intermediate pump station, a pump identical to the intermediate station pumps was placed in the manway and used until the next intermediate pump was installed. This manway pump was equipped with a tank mounted above the pump frame consisting of three 4-foot sections of 20-inch wedge-lock pipe. The pump discharge was connected to the pump column by 2 1/2-inch fire hose. This compact unit was readily installed at any desired elevation in the manway. All the motor pumps were operated automatically by electrode switches.

Crew and Wage Rate

The wage rates in effect during sinking were:

Number of men	Classification	Wage rate per 8-hour day
12	Shaftmen (4 per shift)	$15.82
3	Skiptender-cager (1 per shift)	14.62
3	Hoistmen (1 per shift)	15.90
1	Mechanic (day shift only)	15.82

With the exception of the mechanic, crews changed shifts every 2 weeks.

The crews worked 8 hours, portal to portal, with 20 minutes allowed for travel time each way. The shift schedule was:

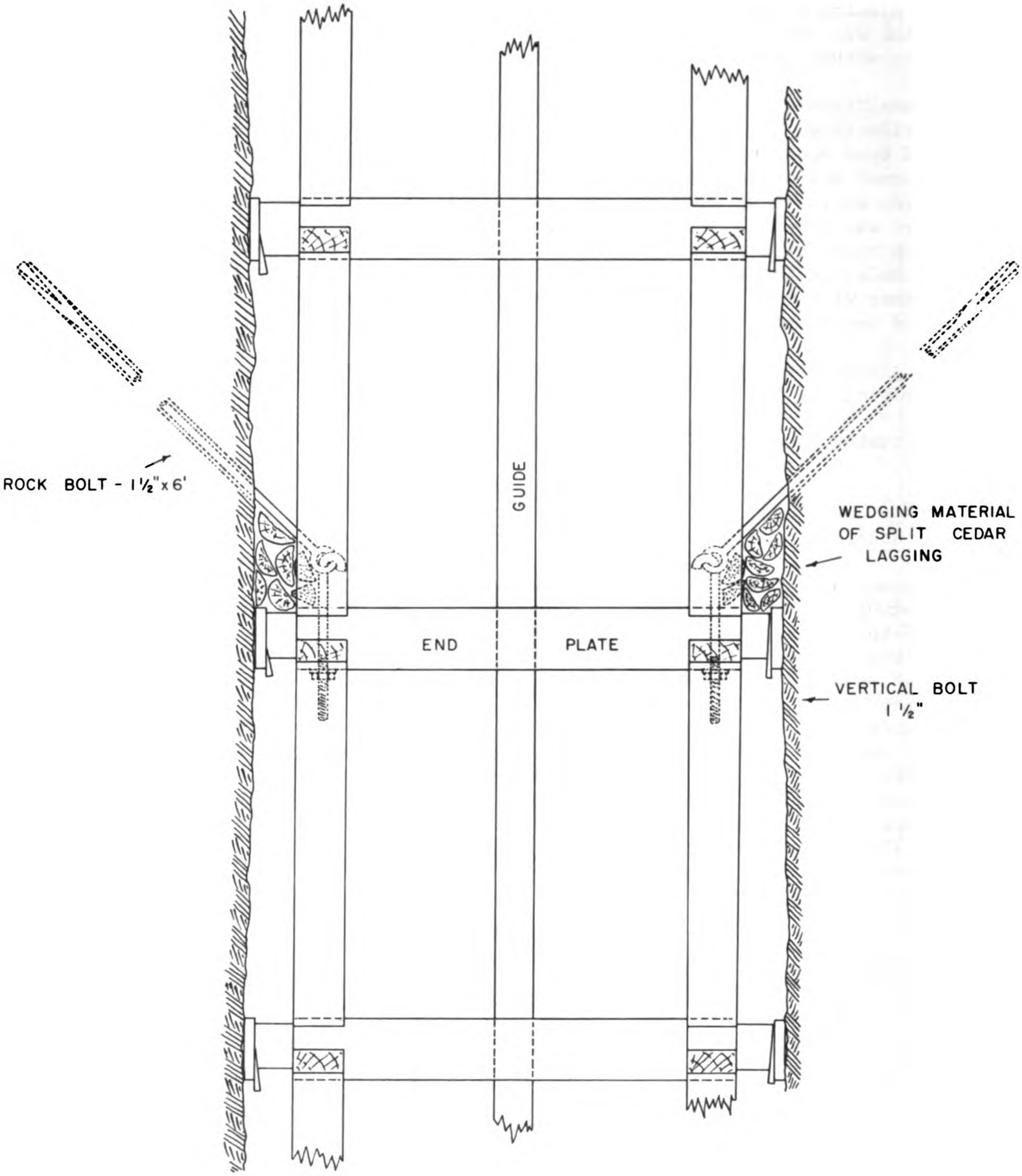

Figure 8. - Rock-bolt bearing set, Crescent shaft.

Day shift	7:00 a.m. to 3:00 p.m.
Afternoon shift	2:40 p.m. to 10:40 p.m.
Graveyard shift	10:20 p.m. to 6:20 a.m.

This schedule permitted the daily change of shifts on the job in the shaft. The mechanic, day-shift skiptender, and day-shift hoistman went on shift at 6:00 a.m. to service the shaft mucker and clamshell bucket. The mechanic and skiptender went off shift at 2:00 p.m., but the hoistman worked until 3:00 p.m. for which he was paid an hour overtime. Occasionally, when mucking was in progress, it was necessary for the skiptender to work until 3:00 p.m.

A bonus incentive system was used, paying the 12 shaftmen $70.00 per foot of timbered shaft when this amount exceeded the guaranteed day's pay. In addition to this amount the 3 skiptenders and the mechanic each received a bonus equal to 40 percent of that received by a shaftman, and the 3 hoistmen received 20 percent of the same amount. This bonus pay was used as the base for calculating overtime pay.

The crew was responsible not only for the shaft advance but for the transportation of timber and supplies from the portal mine yard and for tramming the hoisted rock to the outside waste bin. The mechanic did all the mechanical maintenance that did not require shopwork and spent a large portion of his time handling timber, supplies, and broken rock on the adit level.

COST OF SINKING

Deepening the Crescent shaft was an independent operation. Sinking was on a 3-shift-a-day, 6-day-a-week basis. Time and one-half was paid for all hours worked in excess of 40 hours a week.

The following tables show sinking costs, performance data, and accident experience for deepening the Crescent shaft.

TABLE 1. - Crescent shaft-sinking costs

	Cost per foot	
Overhead	No charge	
Labor - direct		
1. Shift boss	$ 2.75	
2. Shaftmen (includes overtime and bonus)	80.47	
3. Hoistmen (includes overtime plus 20% of shaftmen's bonus for 3 men)	10.26	
4. Skiptenders (includes overtime plus 40% of shaftmen's bonus for 3 men)	11.56	
5. Mechanic (includes overtime plus 40% of shaftmen's bonus for 1 man)	4.28	
6. Electrician (labor - installation)	3.47	
		$112.79

TABLE 1. - Crescent shaft-sinking costs (Con.)

		Cost per foot	
Labor - indirect			
7.	Superintendence	$ 2.75	
8.	Machine shop (repair drills, pumps, shaft mucker, hoist, and compressors. Make hanging rods, pipe clamps, blasting sets, and frame timber)	13.60	
9.	Construction and repair - labor (building and maintenance of waste bin, casing pipe, and some timber handling)	2.15	
10.	Electrician (maintenance)	.87	
11.	Miscellaneous - labor (dry-house attendant, track and tunnel maintenance)	4.73	
12.	Fringe benefits (7% of all labor costs - social security and insurance)	9.60	
13.	Engineering (surveying and geology)	1.29	
	Subtotal		$ 34.99
	Total - Labor		147.78
Supplies			
14.	Bits and drill steel (includes labor for preparing and sharpening)	6.70	
15.	Drill repair (parts)	1.95	
16.	Explosives (powder, detonators, blasting wire, and blasting machine)	9.59	
17.	Timber and lagging (includes all timber)	15.30	
18.	Pipe (6" air line, 6" pump column, 2" water-supply line, and 20" ventilation pipe)	10.24	
19.	Pump repair	.73	
20.	Miscellaneous (spare unit for shaft mucker and all supplies not included in items 14-19)	20.11	
	Subtotal		64.62
Miscellaneous			
21.	Electric power (power for entire project)	4.28	
22.	Garage (delivery of timber and supplies to Hooper tunnel portal and waste removal)	5.49	
23.	Mucker royalty	1.18	
24.	Other (water and communication, including maintenance)	.65	
	Subtotal		11.60
	Total		224.00
Expenditures before start of shaft sinking			
25.	$37,606.87 distributed as follows:		
	Mine labor[1] $10,725.72	$ 5.36	
	Supplies[2] 22,500.54	11.25	
	Miscellaneous 4,380.61	2.19	
	$37,606.87	$18.80	
26.	Total direct and indirect sinking costs (total cost minus expenditures before start of shaft sinking - $224.00 - $18.80) (does not include purchase nor depreciation on service equipment - as compressors, adit level locomotive, hoist, etc.)	205.20	
	Total		224.00

[1] Labor for repairing 1,200-foot level station and labor for rebuilding shaft mucker to fit shaft.

[2] Includes $3,000 for shaft mucker, hoisting ropes, clamshell bucket, portable welder, 3 drifters, 2 sand pumps, 2 shaft-sinking buckets, and spare parts for mucker.

TABLE 2. - Performance data, not including station work

Time worked in shaft (2,000.5 feet)	days	238 2/3
Average progress per 24-hour day	feet	8.4
Average advance per shift per shaftman	do.	0.7
Average advance per bench round	do.	3.1
Average number of buckets per foot		10.3
Average time spent on dead work per foot (time spent by shaftmen on work other than drilling, mucking, and timbering)	minutes	17

TABLE 3. - Accident data, comparison

	Man-hours	Lost-time injuries	Lost-time days	Frequency rate	Severity rate
Crescent shaft project (all shaft work)	50,349	4	235	79.45	4.67
State of Idaho (all underground mining - 1954)[1].	5,947,084	953	55,262	160.25	9.29

[1] McDowell, Geo. A., Mining Industry of Idaho for 1954: 56th Annual Report of the Inspector of Mines, Boise, Idaho, 1954, p. 15.